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CARNIVOROUS PLANT NEWSLETTER

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Front Cover: A large plant of *Nepenthes rowanae* in a swamp on Cape York, with upper, intermediate and lower pitchers. The largest pitchers on this specimen were about 20cm in height (not including the lid). See article on page 36. Photograph by Charles Clarke.

Back Cover: A robust plant of *D. spatulata* var. *gympiensis* with the tallest scape seen during fieldwork. Beside it, and behind it are *D. burmannii* rosettes. Note the clay soil in which the sundews are growing. See article on page 56. Photograph by Robert Gibson.

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D. filiformis var. *filiformis*
D. glanduligera
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D. intermedia—Florida, USA
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D. intermedia—New Jersey, USA
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D. intermedia—Venezuela
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D. rotundifolia—Alaska, USA
D. rotundifolia—New Hampshire, USA
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D. spatulata
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Nepenthes rowanae (Nepenthaceae), a remarkable species from Cape York, Australia

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Keywords: conservation — taxonomy: Australia, *Nepenthes mirabilis*, *Nepenthes rowanae*.

Introduction

The tropical pitcher plant genus *Nepenthes* consists of approximately 85 species, the majority of which occur in Southeast Asia (Jebb & Cheek, 1997). Although Bailey (1897) and von Meuller (1866) described 11 species from the Cape York region of Queensland, Danser (1928) reduced all of these to synonyms of the widespread species, *N. mirabilis* (Lour.) Druce. The only taxon described by Bailey which Danser (1928) considered to possess characteristics that were atypical of *N. mirabilis* was *N. rowanae* Bail., of which Danser wrote, "Only *N. rowanae* shows a character not yet met with in *N. mirabilis*, *viz.* campanulate-infundibuliform upper pitchers. A similar aberration, however, is often met with in several allied species and is certainly insufficient for specific distinction".

In recent revisions of the genus (Stanley, 1982; Jebb & Cheek, 1997; Cheek & Jebb, 2001), Danser's interpretations have been upheld, despite the fact that the type specimens of Bailey's taxa held at the Brisbane Herbarium (BRI) were not examined (and in fact have not been studied in detail since the time of Danser's revision). Moreover, detailed field observations of Australian *Nepenthes* have perhaps never been conducted—much of the key material at BRI was collected by Frank Jardine in the 1890's and specimens collected after that time are nearly all from well-explored, easily accessible localities where *N. mirabilis* is abundant, but aberrant taxa are not.

In 2001, Rod Kruger made several expeditions to Cape York with the intention of relocating *N. rowanae* in the wild. He was successful and noticed that this taxon had several characteristics that made it easy to distinguish from *N. mirabilis*, thereby raising the possibility that *N. rowanae* may be a distinct species. In 2003 we embarked on a formal expedition to Cape York to study this taxon in detail. Our observations showed that *N. rowanae* possesses several stable, significant morphological and ecological characteristics that are not exhibited by *N. mirabilis*. Accordingly, we re-instate *N. rowanae* as a distinct species here. The following text provides the first detailed description of *N. rowanae* and includes ecological notes and information on how to distinguish it from *N. mirabilis*.

Nepenthes rowanae Bail., Qld. Agric. J. 1 (1897), t. s.n. Holotype: *Jardine s.n.* (BRI, AQ#278790), Australia, Queensland, Somerset; Macfarl. in Engl., Pflanzenr. IV, 111 (1908) 69; *Nepenthes mirabilis* auct. non (Lour.) Druce, Danser, Bull. Jard. Bot. Buitenzorg III, 9 (1928) 330; Stanley, Flora of Australia 8 (1982) 8; Clarke, *Nepenthes* of Borneo (1997) 105; Jebb & Cheek, Blumea 42(1) (1997) 64; Cheek & Jebb, Flora Malesiana 15 (2001) 106; Clarke, *Nepenthes of* Sumatra and Peninsular Malaysia (2001) 164.

Emended Description

Subscandent shrub. Stems initially erect, then scrambling, occasionally to a height of 2m, ≤ 4m long, ≤ 12mm in diameter, internodes ≤ 3cm, cylindrical. Leaves coriaceous, petiolate; blade lanceolate, ≤ 40cm long, ≤ 10cm wide, gradually contracted towards the petiole, very gradually tapering at the apex, apex rounded and slightly peltate. Midrib arced throughout in a crescent-like manner from the base to the apex of the blade. Petiole ≤ 10cm long, attachment to

the stem simple, clasping the stem for half of its circumference, the margins decurrent along the stem for 1/2-2/3 of the internode. Tendrils straight, ≤ 60cm long. Longitudinal veins 5-6 on each side of the midrib, pennate veins distinct, running almost straight to the margin from the midrib. Leaf blade has 3-4 longitudinal furrows running throughout its length. Lower pitchers arising abruptly from the end of the tendril, base very broad (to flat in some specimens), pitcher cup broadly ovoid, ≤ 20cm high, ≤ 15cm wide, with a distinct hip in the upper half of the pitcher (often in the upper 1/4). Pitcher contracted from the hip to the peristome, mouth horizontal, rising steeply at the rear, neck absent. Inner surface of pitcher glandular beneath the hip, glands ovate and recessed, 0.01mm wide, ≤ 3600 glands/cm^2. Two wings, often bearing multi-cellular fringe elements over part of their length, extend from just beneath the peristome towards the base of the pitcher. In many mature plants, the wings only extend half-way down the pitcher and rather than possessing fringe elements throughout, they are flattened and expanded, being T-shaped in cross section. Multi-cellular fringe elements, when present, ≤ 5mm long. Peristome ovate in cross-section, except at the rear of the pitcher, where it becomes flattened and expanded, ≤ 20mm wide, the opposite ends often overlapping beneath the lid. Ribs distinct and raised, ≤ 0.5mm apart, ≤ 1mm high. Teeth distinct but short, ≤ 1mm long in most parts, ≤ 3mm long near the apex. Ribs at the front of the pitcher, between the wings, often distinct and raised, ≤ 2mm apart, ≤ 3mm high. Lid ovate, strongly cordate at the base, often indented at the apex, ≤ 8cm long, ≤ 7cm wide, often with two barely-distinguishable keels. Lower surface densely covered with nectar glands, circular to oval in shape, slightly raised. Glands towards the margins circular, c.0.2mm wide, those near the centre ovate, 0.5 × 0.25mm. Spur simple, usually bent, ≤ 6mm long. Upper pitchers infrequently produced, similar in shape and structure to the lower ones, but more infundibular towards the base, with the hip located immediately below the peristome, wings reduced to ribs and the lid more ovate, ≤ 15cm high, ≤ 8cm wide. Inflorescence a cylindrical raceme, peduncle ≤ 20cm long, rachis ≤ 40cm, angular to cylindrical ≤ 8mm wide. The rachis is occasionally subtended by a filiform bract, ≤ 15mm long. Pedicels ≤ 15mm long, lacking bracteoles. Sepals elliptical, ≤ 7mm long. Female inflorescences generally shorter than the males. Fruits ≤ 25mm long, seeds filiform, usually about 15mm long. Indumentum thin and dense on all young parts of the plant except the upper surfaces of the leaf blades, the hairs being long, mostly simple and white in colour. Most hairs are caducous, but a dense covering is retained on the outer surface of the pitcher rim, just beneath the peristome, and on the pedicels. Pitchers generally deep red throughout, but occasionally forms with green pitchers have been observed in the field.

Distribution: Australia (Queensland, Cape York Peninsula, Somerset).
Ecology: Open, wet areas among banksias, pandans and sedges, growing in peat and/or sandy substrates, 0-10m asl.

Known natural hybrids: *Nepenthes rowanae* × *mirabilis*.

Conservation status: *Nepenthes rowanae* is known from several swamps in the northern parts of Cape York Peninsula, but is not known to exist elsewhere. Despite this, all populations currently lie in protected areas. According to the IUCN guidelines (Anon. 1994), a category of Low Risk—Conservation Dependent is proposed.

Etymology: Named in honour of Ellis Rowan (1848-1922), an outstanding botanical illustrator of Australasian plants.

Discussion

Herbarium material of *Nepenthes rowanae* is scant. At BRI there are three specimens that can be unequivocally identified as belonging to this species. The type specimen, *Jardine s.n.* (BRI, AQ#278790), has only one lower pitcher, an illustration of which accompanied Bailey's (1897) original description. The latter was based on this single lower pitcher only, with an accompanying note suggesting that a full description would be provided after more material was obtained from Somerset by Jardine. A second collection by Jardine (*Jardine s.n.* (BRI,

AQ#46873)) consists of several loose fragments contained in a plastic bag (the manner in which they were preserved by Jardine made it impossible to mount them on card). Bailey attached a note identifying these specimens as *N. rowanae*, but never published a more detailed description of this species. Another note attached to these specimens, written by G.T. White, states, "There seems some mixture here but I should say these are the specimens referred to by Bailey in *Agricultural Journal of Queensland* 1. 369. Nov. 1897". However, we interpret all of the material in this collection as belonging to *N. rowanae*. Later, Danser attached a label stating the following, "Further materials of *N. rowanae* Bail., which seems an abnormal form of *N. mirabilis* only". The third specimen (*Whitehouse s.n.* (BRI AQ46888)) appears to have been collected more recently, but no collection date is provided on the label. This specimen consists of a short stem bearing several leaves, a lower pitcher and a female infructescence. Another Whitehouse collection, *Whitehouse s.n.* (BRI AQ46884 (= *N. mirabilis*)), is dated 1943 and it is likely that the material of *N. rowanae* was collected at the same time. Further collections of *N. rowanae* have been made by us and will be deposited at BRI at the conclusion of our research.

Nepenthes rowanae is an impressive species that produces richly coloured, ovoid to oblong lower pitchers that may occasionally reach 20cm in height. Pitcher shape is somewhat variable—the most extreme forms produce squat pitchers that are as wide as they are tall, but the most common ones have pitchers that are about twice as tall as wide. A key characteristic is that the pitcher hip is always at least half-way up the pitcher cup, and usually higher. The stems rarely attain lengths greater than 3m before dying off and being replaced by off-shoots from the main rootstock, which is large, woody and resistant to low intensity fires (which are common during the dry season). This growth habit is also exhibited by *N. rajah* Hook.f. Indeed, mature plants of *N. rowanae* are superficially similar in appearance to that species. As in *N. rajah*, aerial pitchers are only produced occasionally. They are similar in overall structure to the lower pitchers, but usually lack the multi-cellular elements on the wings and are less abruptly contracted at the base. The hip is always located immediately beneath the peristome, and the pitcher walls are generally contracted above the hip, towards the peristome.

Although *N. rowanae* can be distinguished from most forms of *N. mirabilis* by its pitchers, two characteristics of the leaf blade provide a more reliable means of identification (see Table 1). First, the apex of the blade of *N. rowanae* tapers very gradually along the tendril, more so than in any other species (see Front Cover). This feature has not been observed in *N. mirabilis* to date. The margins of the blade may be straight or undulating in this region. Second, the apex itself is usually rounded and slightly peltate, as in several other species of *Nepenthes* (see Clarke, 1997, 2001), but unlike *N. mirabilis*. Also, at the point where the petiole joins the stem, the margins are decurrent for at least half the length of the internode, often more. The margins may also be slightly recurved towards the base, arcing back towards the leaf. The insertion of the petiole in *N. mirabilis* is generally simple, but in some forms from Cape York, may also be decurrent for some distance along the internode.

Despite these significant differences, *N. rowanae* is clearly a very close relative of *N. mirabilis*. An obvious problem with the elevation of *N. rowanae* to specific rank is that some characteristics that have been considered to be diagnostic of *N. mirabilis* in the past (e.g., the fimbriate margins and longitudinal furrows of the leaf blades), now apply to two species and should therefore be used with greater caution, particularly when taxa from Australia or New Guinea are examined. In other regions, it is unlikely that this problem will arise. To date *N. rowanae* is known only from the Cape York region of Australia. However, the similar habitats are widespread in southern New Guinea and it is possible that this species also occurs there.

The existence of an endemic *Nepenthes* species in Australia is likely to generate considerable interest among private enthusiasts of the genus. The potential for some wild populations to come under pressure from illegal collecting of plants is considered to be significant. For this reason, precise locality information is not provided here. Rather, the ranges of these taxa are stated as lying within the bounds of the now defunct cattle station owned and operated by the Jardine family (the homestead of this station was known as "Somerset", but the property itself was actually called "Lockerbie"). Since the station's demise, the area it occupied has been returned in part to its traditional owners, the Injinoo people, or gazetted as National Parks. Exact locality information will be provided to the staff of QPWS and BRI at the conclusion of this research, to assist

Figure 1: A lower pitcher of *Nepenthes rowanae*.

Figure 2: An intermediate pitcher of *Nepenthes rowanae*.

Figure 3: *Nepenthes mirabilis* habitat in Cape York, Queensland; *N. mirabilis* visible at the right. *Nepenthes rowanae* habitat is similar.

the relevant management authorities in conserving key populations of *Nepenthes*. Although the illegal collection of wild plants is considered to be a potential threat to *N. rowanae*, by far the greatest problem is destruction of plants by feral pigs. It appears that many plants are uprooted and killed by their activities each year, and any future management efforts will have to address this problem ahead of any others. Although this type of damage appears to be widespread, it does not seem to be resulting in an obvious decline in population sizes at this stage, but accurate surveys of population size and fluctuations would be of considerable value to conservation efforts.

Nepenthes rowanae has recently entered cultivation and some desirable forms have already been given informal varietal names by horticulturists. At the time of writing, no such forms or varieties have been validly described. Although a variable species, we are not presently of the opinion that any taxa below the level of species warrant such description for scientific purposes. We have observed putative natural hybrids between *N. rowanae* and *N. mirabilis* and these may be difficult for amateurs to identify.

The seasonal growth and reproductive patterns in *N. rowanae* are yet to be fully documented, but from observations of wild and cultivated plants, it appears that growth of stems and pitcher production is maximal both before and at the end of the wet season (usually December-April, the southern summer). Slower, steady growth occurs throughout the dry season (May-October), but rates may decrease somewhat towards the end of the "dry". During the wet season, growth may stop completely, presumably because the habitats in which this species grows are submerged during this time. What becomes of the pitcher contents (or indeed the functionality of the pitchers) during the wet season is unknown, but few, if any new pitchers seem to be produced during this season.

Material Examined

Collections were examined at Brisbane (BRI), Lae (LAE), Singapore (SING), Bogor (B) and Kew (K). Field observations were conducted at various localities in National Parks on Cape York Peninsula in July 2003. A list of specimens examined at BRI (where Bailey's types are held, along with the most comprehensive collection of Australian Nepenthaceae) follows. All specimens were identified as *Nepenthes mirabilis*, except for those denoted as belonging to *N. rowanae*. Holotypes of other taxa described by Bailey are also noted, but are considered to be

Characteristic	*Nepenthes mirabilis*	*Nepenthes rowanae*
Morphology of leaf blade.	Acute to rounded.	Contracted towards the apex, then continuing along the tendril as a narrow, acute, extension.
Insertion of tendril to leaf blade.	Simple.	Peltate.
Pitcher wings.	Simple, bearing multicellular fringe elements.	Often flattened at front, forming a T-shape in XS, multicellular fringe elements often present.
Leaf blade texture.	Usually chartaceous.	Strongly coriaceous.
Leaf blade attachment to stem.	Simple, or rarely decurrent for 1/3 the length of the internode.	Decurrent for at least 1/2 the length of the internode, usually more.
Gland density in lower portion of pitcher.	1600-2500 cm^{-2}.	Approximately 3600 cm^{-2}.
Position of pitcher hip in upper pitchers.	Mid-way, to lower half.	Upper quarter.
Position of pitcher hip in lower pitchers.	Lower third to quarter.	Immediately beneath peristome.

Table 1. Distinguishing characteristics between *N. mirabilis* and *N. rowanae*.

conspecific with *N. mirabilis*. BRI acquisition numbers are provided in addition to the collection numbers, as many collectors did not number their specimens.

Anonymous (BRI AQ#294686, Holo—*N. bernaysii*), (BRI AQ#478600), (BRI AQ#478601)—Armbrust s.n. (BRI AQ#278784, Holo—*N. armbrustae*)—Bailey 33 (BRI AQ#46889)—Bean 13595 (BRI AQ#671300)—Brass 18727 (BRI AQ#325078), 18728 (BRI AQ#325077), 18850 (BRI AQ#325084), 19647 18728 (BRI AQ#325079), 19514 (BRI AQ#325082), 19601 (BRI AQ#325083), 19489 (BRI AQ#325081), 19488 (BRI AQ#325080)—Brooker 4081 (BRI AQ#101575)—Clarkson 7330 (BRI AQ#409006), 2876 (BRI AQ#390487), 4171 (BRI AQ#381498)—Conn 3784 (BRI AQ#626351)—Dalliston CC285 (BRI AQ#409705)—Dodson s.n. (BRI AQ#3594)—Ellis s.n. (BRI AQ#46879)—Forster PIF4083 (BRI AQ#429579), PIF15454 (BRI AQ#601057), PIF10571 (BRI AQ#545072)—Garraway s.n. (BRI AQ#278780), s.n. (BRI AQ#278774), s.n. (BRI AQ#46894)—Gittins 1023 (BRI AQ#46887)—Haskett s.n. (BRI AQ#46868)—Hyland 2495 (BRI AQ#46871), 5470 (BRI AQ#46868)—Jago 3586 (BRI AQ#584604)—Jardine C. s.n. (BRI AQ#278782, Holo—*N. cholmondeleyi*)—Jardine F.L. s.n. (BRI AQ#278778, Holo—*N. jardinei*), s.n. (BRI AQ#278776, Holo—*N. moorei*), s.n. (BRI AQ#278790, Holo—*N. rowanae*), s.n. (BRI AQ#46883), s.n. (BRI AQ#46880), s.n. (BRI AQ#46886), s.n. (BRI AQ#46893), s.n. (BRI AQ#46873—*N. rowanae*), s.n. (BRI AQ#46876), s.n. (BRI AQ#278788, Holo—*N. albolineata*), s.n. (BRI AQ#278786, Holo—*N. alicae*), s.n. (BRI AQ#46870), s.n. (BRI AQ#46872), s.n. (BRI AQ#46874), s.n. (BRI AQ#46885),—Jobson 788 (BRI AQ#510913)—Johnson 5121 (BRI AQ#562916)—Jones s.n. (BRI AQ#46892), s.n. (BRI AQ#46890)—Kanis 2076 (BRI AQ#337084)—Lavarack s.n. (BRI AQ#330212)—Lazarides 8145 (BRI AQ#222665)—Marks s.n. (BRI AQ#417276), s.n. (BRI AQ# 417279), s.n. (BRI AQ#46881)—Middleton 80001D (BRI AQ#323704)—O'Reilly 402 (BRI AQ#458020)—Scarth-Johnson 848A (BRI AQ#322760)—Smith 11924 (BRI AQ#2849), 12466 (BRI AQ#1153)—Specht W171 (BRI AQ#103009), W389 (BRI AQ#114845)—Wassell s.n. (BRI AQ#46882)—Webb 5994 (BRI AQ#46927), 3217 (BRI AQ#46891)—Whitehouse s.n. (BRI AQ#46887), s.n. (BRI AQ#46888—*N. rowanae*), s.n. (BRI AQ#46875), s.n. (BRI AQ#46884), s.n. (BRI AQ#46869)—Williams s.n. (BRI AQ#1654)—Wilson 8190 (BRI AQ#625667).

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The Effect of Copper and Iron Ions on the Growth of the Bladderworts *Utricularia gibba* and *U. macrorhiza*

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Keywords: chemistry: habitat — field studies: *Utricularia gibba, U. macrorhiza.*

Introduction

In this paper, we examine correlations between the concentrations of metal ions, specifically copper as Cu^{2+} and iron as Fe^{3+}, and the growth characteristics of two aquatic bladderworts (*Utricularia gibba* and *U. macrorhiza*). Our work involved field observations at several *Utricularia* sites in the Middle Atlantic States (USA), transplant studies at two locations within one marsh, and laboratory analyses.

Copper and iron are both micronutrients required for healthy growth in plants (Raven, 1971). Metal ions dissolved in H_2O form metal hydroxides and hydronium ions, making the solution aeidic. In such acidic solutions, decomposition of plant matter is slowed, leading to a deficiency of nutrients and minerals (Kosiba, 1992).

Copper was chosen for study because, while it is a necessary micronutrient, in high concentrations it can be harmful to plants (Raven, 1971). In addition, many of the sites visited were surrounded by farmland where agricultural fertilization practices are likely to result in elevated copper concentrations in surface water. Iron was chosen for study because there were two areas in one marsh in our sample where old iron construction equipment lay. Presumably, the iron ion concentrations are elevated in these sites.

We hypothesized that the bladderworts' growth rates would increase with higher concentrations until the amount of metal ions became toxic for the plants, causing either a decrease in growth rate or death.

Methods

During a ten week period, weekly field excursions were made to a variety of sites. Measurements were taken at these locations for pH, salinity, temperature, nitrate, and both total light intensity and photosynthetic active radiation. Copper levels at these sites ranged from 0.55 to 1.7 $\mu g\ L^{-1}$ (mean value: 0.79 $\mu g\ L^{-1}$, standard deviation 0.33 $\mu g\ L^{-1}$) while iron levels ranged between 0.12 and 2.9 $\mu g\ L^{-1}$ (mean value: 1.3 $\mu g\ L^{-1}$, standard deviation 0.94 $\mu g\ L^{-1}$).

Water samples were collected at each site, and the copper and iron levels were measured using the colorimetric Neocuproine and Phenanthroline methods, respectively (Greenberg, *et al.*, 1992). In the Neocuproine method, the absorbance was measured at 457 nm, while for the Phenanthroline method, the orange-red complex was analyzed at 510 nm (Standard Methods, 1992).

Transplantation experiments were run at Big Marsh, Maryland (also known as Echo Hill). Seven permanent sites were chosen at Big Marsh as described in McDermott & Darnowski (2001), and in this paper we use the same set of site # locations (Sites #1-7). Two of the sites (#1, #5) were adjacent to rusting iron equipment, and we theorized these sites might have elevated iron levels in the water.

Six specimens of *U. macrorhiza* and six specimens of *U. gibba* were selected from a population we maintain in our greenhouse. These plants originally came from sites #5 and #7 (i.e. twelve plants total). Their initial masses and lengths of the main stem were recorded. Each bladderwort was attached by nylon filament fishing lines to an anchor (made of a sock filled with rocks) and to a Styrofoam ball to act as a buoy in the water. Three specimens of each species were placed in the swamp next to a rusting iron crane (site #1). The remaining six bladderworts were positioned under a tree by another channel of water (site #2). The light intensity was approximately the same at both sites. The second site was approximately 150 meters from the rusting crane, i.e. far enough from it

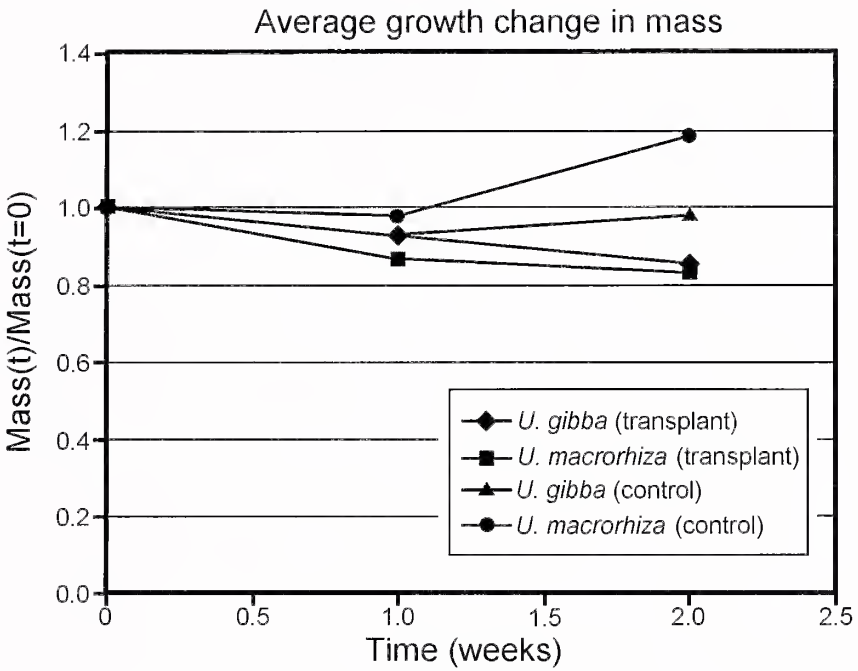

Figure 1: Average relative change in growth in mass for control and transplanted plants.

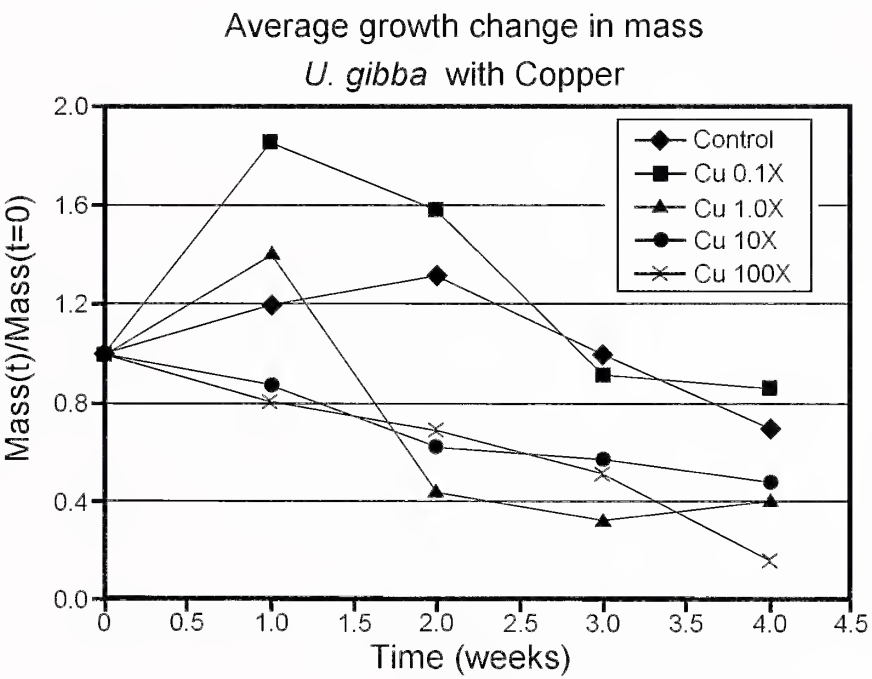

Figure 2: Relative change of *U. gibba* mass, in various copper concentrations.

to probably not be significantly contaminated by it. These transplantation sites were visited every 2 weeks for 4 weeks total. On each visit, the bladderworts' mass was recorded.

For the laboratory experiments, three repetitions were set up about a week apart and each repetition was carried out for a total of 4 weeks. For each repetition, *U. gibba* and *U. macrorhiza* plants (from site #1) were placed in 500 mL containers filled with ddH_2O as controls; eight of each species were placed in 500 mL of 0.1X, 1.0X, 10X and 100X separate copper and iron solutions. (This scale was set by Raven (1971), where 1.0X normally yields healthy growth in plants, where 1.0X levels are 0.01 mg L^{-1} (for copper) and 1.0 mg L^{-1} (for iron)). Copper was dissolved into ddH_2O in the form of cupric chloride ($CuCl_2 \bullet 2H_2O$) and iron in the form of ferric chloride ($FeCl_3$).

In order to ensure that no confounding factors affected the growth of the bladderworts and to emulate natural environmental conditions, the light intensity was adjusted in the lab. All plants were grown under wide spectrum fluorescent bulbs. Light levels in the growing area were 1000-2500 lux (total incident radiation) and 15-35 μmol m^{-2} s^{-1} PAR.

Since carbon dioxide levels in the swamps and marshes where the bladderworts are found are higher than those found in the ddH_2O in the lab (McDermott & Darnowski, 2001), CO_2 was bubbled into the containers. The carbon dioxide source was a sucrose and yeast reactor per the description by Camilleri (1998).

The mass and length of the cultivated bladderworts were measured every week for a period of 4 weeks.

Results

The majority of sampling sites had pH<7 and were shaded to 0.3-45% compared to direct sunlight. The Cu and Fe levels at the control site (site #2) were 0.70 μg Cu L^{-1} and 1.1 μg Fe L^{-1}, respectively. At the transplantation site (site #1), they were 1.7 μg Cu L^{-1} and 1.2 μg Fe L^{-1}, respectively. As shown in Figure 1, transplanted specimens in the higher Cu and Fe site had lower growth rates with respect to the controls.

In the laboratory, as ion concentrations increased, decreases in growth were observed. For example, both species usually had the highest growth rates in the control and 0.1X solutions, followed by the 1.0X solutions. Although most plants in 100X solutions declined, *U. gibba* survived in the 100X Cu solution and *U. macrorhiza* survived in the 100X Fe solution (see Figures 2-5).

Discussion

The hypothesis made at the beginning of this experiment was that the bladderworts' rate of growth would increase with the concentration of metal ions and then decrease after the optimal point was reached and the concentration became toxic. The observation that the two species were found in different areas of the sampling sites suggested that they had different preferences or living habitats. Accordingly, only *U. gibba* were found at site #1 which contained high amounts of copper. Meanwhile, *U. macrorhiza* were found in other sites rich in iron.

As assumed, samples from site #1 (old iron machine) and site #5 (rusting iron dock) contained high Fe and Cu ion concentrations. The transplanted specimens at site #1 grew in an environment analogous to the Fe 10X-100X and Cu>100X solutions used in the laboratory experiments. Like the plants grown in these solutions, the transplants had low or no growth rates. On the other hand, the controls at site #2 grew in an environment of moderate and non-toxic Cu and Fe levels and displayed normal growth rates.

In the laboratory studies, plants grown in the 0.1 and 1.0X solutions had the highest growth rates while very low growth and sometimes death occurred at 10X or 100X concentrations. *Utricularia gibba* survived in the concentrated Cu solution while *U. macrorhiza* did the same in high Fe solutions. Both species, however, died in high concentration solutions of the other respective ion. These results suggest that *U. gibba* and *U. macrorhiza* can adapt to environments rich in Cu and Fe, respectively.

The data show that the growth rate of these two bladderwort species remained positive with increasing concentrations of Cu and Fe ions until the amounts became toxic. This conclusion corroborates findings published by several other researchers. For example, a study determined that the growth rate and biomass of *U. vulgaris* increased in concentrations of humic aeids from 1- 4 mg L^{-1} but are seriously inhibited in higher concentrations (Kosiba, 1992). In addition, the transplantation and laboratory experiments imply that *U. gibba* expresses tolerance to high concentrations of

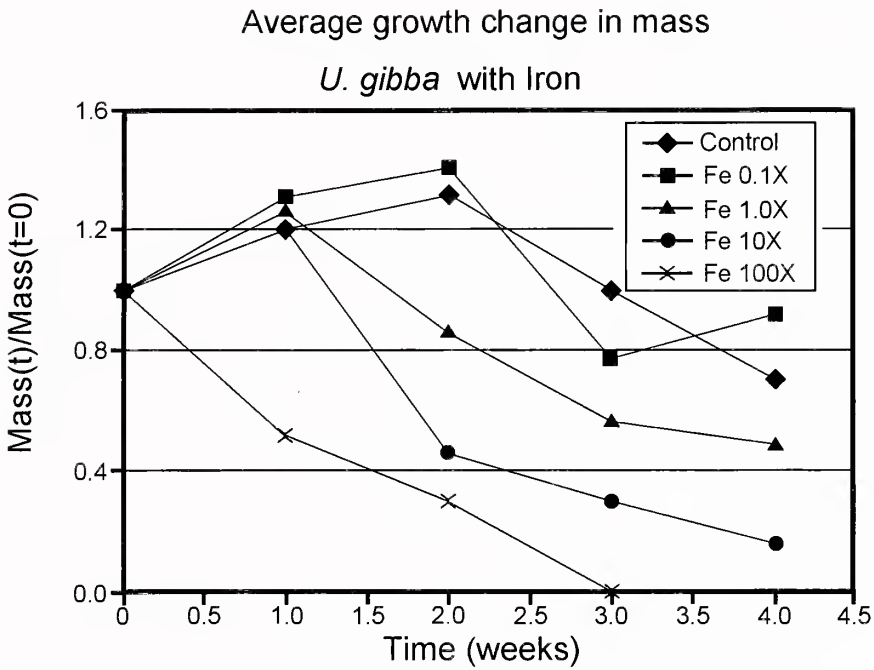

Figure 3: Relative change of *U. gibba* mass, in various iron concentrations.

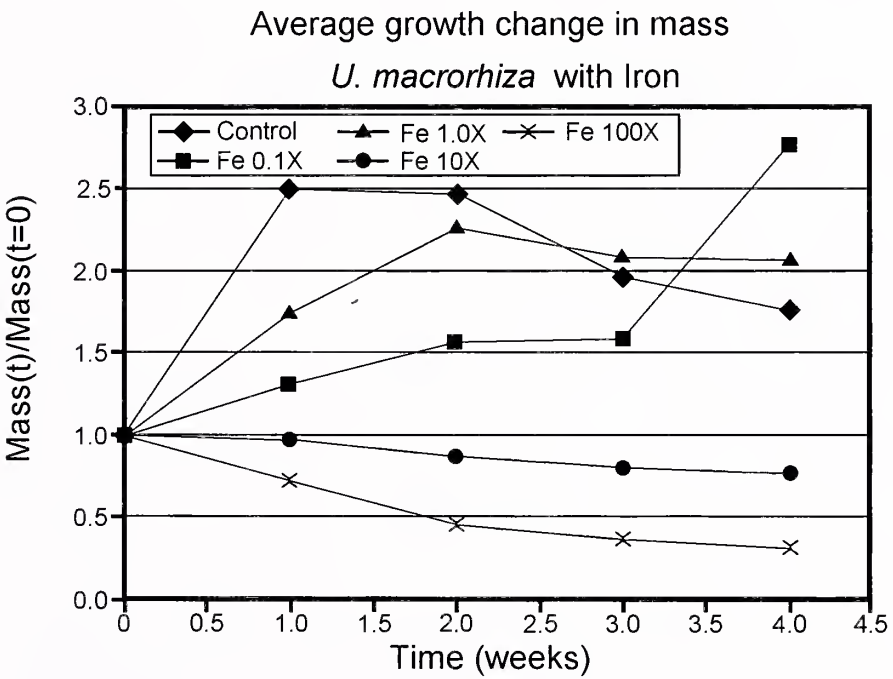

Figure 4: Relative change of U. macrorhiza mass, in various iron concentrations.

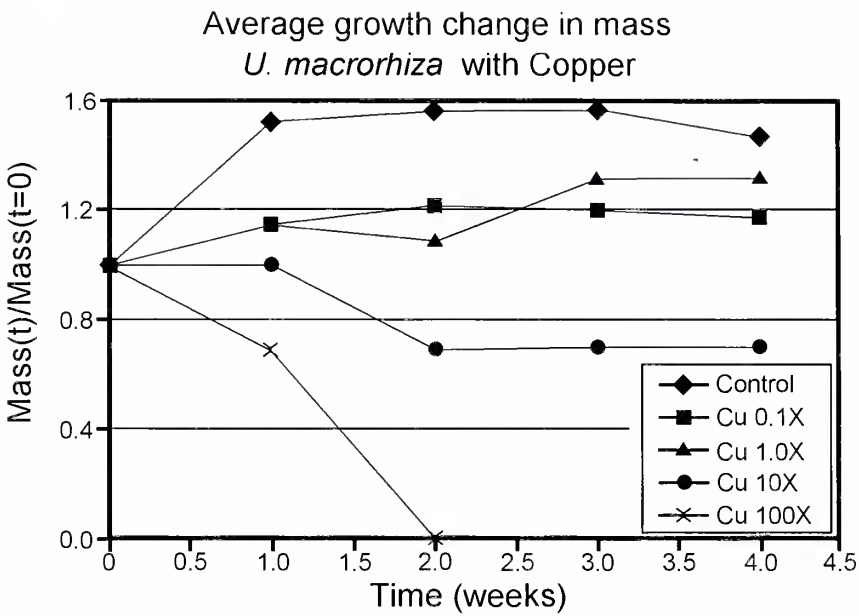

Figure 5: Relative change of *U. macrorhiza* mass, in various copper concentrations.

Cu while *U. macrorhiza* can survive in high Fe concentration environments.

Transplantation experiment specimens were surrounded by organic matter that may have affected growth (Kosiba, 1992) and may account for the slight difference in results between the transplantation and laboratory experiments. These results can be used in further research to explore whether bladderworts prefer acidic environments or gravitate towards them because they can outcompete other plants there.

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Nepenthes argentii on Sibuyan Island

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Keywords: travelogue: *Nepenthes argentii*, *N. sibuyanensis*, Philippines.

Sibuyan is one of the less known of the seven thousand islands that comprise the Philippines. It became more prominent among botanists at the end of the 1990s, when two new and interesting species of *Nepenthes* were described from the island: *N. sibuyanensis* (Nerz *et al.*, 1998) and *N. argentii* (Jebb & Cheek, 1997).

Although Sibuyan lies in the heart of the Philippines (north of Panay; 12° north latitude), it is secluded from other islands—the nearest are Tablas and Romblon, and together with these it creates an autonomous province surrounded by the Sibuyan Sea. Sibuyan is only 445 km^2 in area. The 47000 humans on the island are concentrated in the nine coastal villages, at elevations up to 100 meters. Their food is based mainly on agriculture and fishery.

Interior to its narrow (5 km) flat coast, a steep mountain massif rises to a peak of 2058 meters on Guiting-Guiting. The climate is tropical, monsoonal, and the temperatures on the coast almost never fall below 20°C, although it is colder at the higher elevations (in January, during our visit, the temperature at 1500 m a.s.l. dropped to 13-15°C at night). Strong rains last from November through January; milder rains occur during the rest of the year. The mountainous interior's unique altitudinal zonation of vegetation is largely intact, and in February 1996 the Philippine government declared 160 km^2—e.g. approximately one third of the territory of the whole island of it to be protected natural area.

We set out for the peak Guiting-Guiting on the second of January, 2001. There were not many remnants of original vegetation between the villages; most of the trees serve for local usage purposes. At the beginning of the ascent a barely discernable path coils through the forested slope, upon which grows relatively undamaged lowland woods. Our packs were heavy (we had to carry our drinking water) and as the path became very steep, our feet sunk into the red, slippery soil. At about 400 m a.s.l. we saw our first *Nepenthes*: seedlings, young plants with basal rosettes, and stems of older plants climbing on the trees to the height of 5 m. According to the literature, this is *Nepenthes alata*, a species mentioned by almost all the botanist visitors to Sibuyan. However, there are some doubts whether it really is *N. alata*, for it lacks the typical appendage on the lower surface of the pitcher lid (Mann, 1998). The plants we observed did not have the lid appendage. It is obvious that the *N. alata* complex deserves more detailed observation.

At approximately 500 m a.s.l. the forest becomes submontane, and interesting plant genera such as the conifer *Falcatifolium falciforme* (Podocarpaceae) increase in number. Between 800 m and 1000 m 2-3 m tall thick and impenetrable bamboo thickets dominate. Above 1000 m the conifers *Dacrydium beccarii* and *Phyllocladus hypophyllus* (both Podocarpaceae) appear and at this place we located the endemic *N. sibuyanensis*. The species was described firstly by J. Nerz (1998), although it had been originally collected in the eighties by Argent. To our knowledge, there exist only six records of this plant in herbaria (cf. Cheek & Jebb, 2001). *Nepenthes sibuyanensis* is a robust *Nepenthes* from the group *Insignes*, the colour and shape of the traps make it distinct from *N. ventricosa* and *N. burkei*. *Nepenthes sibuyanensis* has the largest pitchers of this trio, reaching up to 20 cm. The colour of the traps varies from yellow-green with red spots to almost dark red (facing sun). The lower pitchers have an ovoid shape and a remarkably long ten-

dril which tends to plunge the pitchers into the substrate, presumably to increase their chance to ensnare a victim, and in open areas it also helps to plants to stabilize them in strong winds. We saw upper pitchers only once—there is no mention of them in the species description—and they were narrowly infundibuliform. Being a mountainous species that occurs from 1200-1800 m a.s.l., it does not grow to a great height, and plants above 1 m tall are rather exceptional. *Nepenthes sibuyanensis* grows mostly in shrubby formations outside the borders of woods and on open grassy spots exposed to wind and fog. At its lower elevations, it always occurs on exposed rocky points where no tall trees grow.

About 1200 m a mountainous misty forest (dominated by *Lithocarpus* and *Castanopsis*) grows with crooked stems, richly covered by mosses, *Selaginella*, ferns and a number of miniature orchids. Thick shrubby vegetation dominates at 1500 m above sea level with the majority of the family Melastomataceae, Ericaceae, Rubiaceae, Myristicaceae, Goodeniaceae and Dilleniaceae. The only prominently protruding and sparsely growing wood species is *Dacrydium beccarii*. Inflorescences and infructescence of *N. sibuyanensis* protrude above the level of shrubbery; it abounds here. On a slightly trodden path we found a great number of seedlings struggling to survive under the dense shrub canopy. High humidity, recurring mists and rainfalls, strong streaming winds, and ultramafic soils characterise this area.

The peaks of Guiting-Guiting are a host for another, even more challenging species—*Nepenthes argentii*—named after the British botanist Argent who discovered it in 1989. Jebb & Cheek described it in 1997 on the basis of Argent's collection and aroused a great interest among the botanists and growers of carnivorous plants, in part because it is the smallest known *Nepenthes* in the world. When mature, the rosettes have the maximum average diameter of only 10 cm, and the stem typically grows to only 30 cm long. The traps average 4.5 cm tall and 2.5 cm wide. The species produces striking, rusty haired, straight tendrils and a specially prolonged peristome, which reaches to the lid in a Y-shape, neither of which is shared by any other known *Nepenthes*. *Nepenthes argentii* only grows around the peak of Guiting-Guiting at 1400-1900 m a.s.l. According to Argent's notes, it grows in the shade of tiny shrubs, and the traps descend into the accompanying grassy vegetation. Only the inflorescence protrudes over the shrubbery. Argent writes also about the capability of the species to stay above the slowly accumulating layer of organic material. Cheek & Jebb (2001) compare this behaviour to *Drosera rotundifolia*, which similarly keeps itself on the surface of peat mosses.

From our observations we conclude that *N. argentii* is almost an obligate petrophyte growing in the rock crevices or among boulders, where it may avoid the surrounding low vegetation. We encountered the most vigorous individuals in such environments and we conclude that it is their optimal growing place. This requires further study. We did not find any plants under the shrubs, but cannot exclude the possibility of having missed them. *Nepenthes argentii* is not very frequent and the whole population consists of some hundreds of plants—the only ones in the world! We counted 14 rosettes in the largest group, but whether it was an individual plant or more plants in one bunch, we are not sure. Most of the plants consisted of an individual rosette usually with very low stems; the maximal measured height was 25 cm.

The upper parts of Guiting-Guiting (1600-1770 m a.s.l.) mark the borders of the range of *N. sibuyanensis*. Here *N. sibuyanensis* occupies places similar to those occupied by *N. argentii*—in the cracks of boulders and in the short alpine vegetation. The plants are more exposed to radiation and have much more full coloured traps.

While January was a month of vigorous seed production for *N. sibuyanensis*, it was not the case for *N. argentii*. We found only two old infructescences, so the species probably mostly flowers during the summer months. (Argent and Reynoso collected the type specimen, with an inflorescence, in August; Jebb & Cheek, 1997). Because of the interest in this plant by hobbyists, and its small population, *N. argentii* may be threatened by collecting. Its primary protection for survival is afforded by its distant habitat that is so difficult to access. (Fortunately, this plant is being successfully propagated in-vitro and beautiful specimens are being sold by at least one carnivorous plant nursery.)

Like with so many other montane species, the cultivation of *N. argentii* is not likely to be

Figure 1: Guiting-Guiting looks rather rocky but there is quite dense vegetation on it; fogs and rains are very common features there. Photograph by Vlastik Rybka.

Figure 2: The largest population of *N. argentii* that we observed. Photograph by Vlastik Rybka.

easy. It will certainly demand low temperatures with daily maxima not exceeding 25°C, high humidity, and above all excellent drainage. These assumptions are now being tested in the Prague Botanical Garden. The first two bought plants we cultivated in a sealed cultivation chamber at an almost constant temperature of 20°C, and artificial lighting. Three months later we moved them, along with three newly acquired plants, to our new greenhouse where the temperatures are cooled to 12-20°C, and the air is actively circulated through the greenhouse. A fog system keeps the humidity high. The growth rate of plants is roughly one leaf per month and in December 2003 they started to produce their first pitchers. Still, the species remains extremely difficult in cultivation. It requires high amounts of light and suffers visibly during the short days of winter. The substrate must be well drainaged, we use mixture of peat, chark coal, Styrofoam and vermiculite.

Nepenthes sibuyanensis and *N. argentii* share an interesting feature expressed in the shapes of their seeds. While most *Nepenthes* species have filiform seeds with long papery ends which facilitate wind transportation (Cheek & Jebb 2001; Clarke 2001), both of the upland species on Sibuyan have more cylindrical, robust seeds lacking appendages. This shape prevents the seed from being blown away from suitable habitat by the continuous, stiff breezes, but allows the transfer of the seeds for short distances by water (i.e. rainfall and streamlets). Similar shape adaptations are seen on *Nepenthes pervillei* (an island adapted species from the inselbergs of Seychelles; Fleischmann *et al.*, 1996), and also on *N. northiana* (a Bornean species adapted to growing on steep calcareous walls). Other *Nepenthes* growing on small isolated locations may have similarly modified seeds, but we have not found references to species with seeds that are shaped differently from the normal filiform mode.

In our experience, seeds of *N. sibuyanensis* germinate in enclosed plastic boxes after three weeks at 22-24°C, under 12 hours of artificial lighting. The first true (non-cotyledonous) leaves appeared two months after germination. The leaves of our plants reach 2-5 cm long, and all bear small traps within one year. According to our experiences it is one of the easiest montane *Nepenthes* to grow; it survives summer temperatures over 30°C, and endured short exposures to temperatures as high as 40°C without any damage. During a winter heating failure it was exposed to temperatures as low as 2°C, and responded only by producing a tiny amount of reddening in the leaves.

The island Sibuyan, along with Palawan, is probably the most preserved and the most botanically interesting of the islands of the Philippines. When we consider the latest descriptions of *Nepenthes*, how many as yet not described species of the less popular, noncarnivorous plant groups are still hidden on the slopes of Guiting-Guiting? Unfortunately because of the uneasy political situation on the Philippines and because of the hard accessibility of the island this question will remain unanswered for at least the near term.

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Initial Studies on *In Vitro* Germination and Early Seedling Growth of *Nepenthes truncata* Macf.

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Keywords: cultivation, *Nepenthes truncata*, tissue culture.

In order to develop and establish a protocol for *in vitro* seed germination and early seedling growth for *Nepenthes truncata* Macf., we designed a study to test the effects of different sterilization methods as well as seed soaking treatment, culture medium, and salt concentration.

A series of sterilization trials was performed to determine the minimum amount of sterilization that could produce clean cultures without reducing seed viability. Successive treatments of 3% hydrogen peroxide, 10% Zonrox® bleach and 70% Johnson's® isopropyl alcohol provided the most satisfactory results on sterilization without reducing the seed viability. This protocol resulted in 90.8% sterilization and 83.7% germination based on a sample size of 520 cultures containing 10 seeds each; the seeds were collected from the wild and stored for two weeks in silica gel prior to sowing. Seed pretreatments include: soaking in 10% table sugar solution and hardening involving 24 hours of soaking in distilled water and 24 hours of air-drying. All the culture media tried con-

Figure 1: Sample 125 ml Erlenmeyer flasks topped with aluminum foil and paper sheets, and 200 ml food jars with metal twist-off closures from the *in vitro* germination experiments. Seedlings in the Erlenmeyer flask show advanced growth, possibly due to the greater light transmission allowed by the vessel and more efficient exchange of gases between the external and internal environments allowed by the type of closure.

tained the respective basal salts plus full Murashige and Skoog (MS) iron source and vitamin supplements. Two types of culture vessels were used in the experiments; 125 ml Pyrex® Erlenmeyer flasks capped with paper sheets and, interior to that, unvented aluminum foil secured by rubber bands, and 200 ml food jars with unvented metal twist-off closures. Each vessel contained 25 ml of the specified medium. The cultures were maintained under 25±2°C temperature and 14 hours light which were provided by 40 W fluorescent tubes at 20 cm above culture level.

The main and interaction effects of seed soaking treatments, medium, and salt concentration on the *in vitro* germination of *N. truncata* seeds were studied based on the initial germination percentage (IGP), germination rate (GR) and final germination percentage (FGP). The IGP was recorded after 18 days in the germination medium while GR and FGP yields were taken after 74 days. To document the progress of germination percentage yields in each experimental unit, measurements were recorded every 7 days and the GR values were calculated based on the formula:

$$GR=(FGP-IGP)/T,$$

where T is the number of days that elapsed between the date when the maximum FGP was achieved and the date that the IGP was recorded.

To determine the most suitable medium for *N. truncata* seedlings, the effects of different media on the growth and development were evaluated considering morphological properties such as pitcher formation, leaf condition, shoot length, and root length that were assessed using devised scoring systems for each parameter.

Our results indicate that soaking in 10% table sugar solution significantly facilitated early germination for both flask and jar cultures. The highest IGP was attained in flasks treated by the com-

Table 1: The effects of seed soaking treatment, medium, and concentration on final germination percentage of *Nepenthes truncata* seeds sown in flasks and jars.[1]

		Final Germination Percentage (FGP)			
		Erlenmeyer flask		Food jar	
Medium	Concentration	Sugar solution	Hardening	Sugar solution	Hardening
Control	(no nutrients)	81	86	77	81
MS	1/4	83^{cd}	94^{ab}	76^{ab}	87^{a}
	1/2	90^{abcd}	94^{ab}	79^{ab}	78^{ab}
	3/4	84^{bcd}	88^{abcd}	80^{ab}	83^{ab}
	1	84^{bcd}	94^{a}	79^{ab}	86^{a}
	Mean	85	92	78	84
WPM	1/4	94^{abc}	91^{abcd}	72^{ab}	74^{ab}
	1/2	85^{bcd}	88^{abcd}	72^{ab}	72^{ab}
	3/4	86^{abcd}	85^{abcd}	77^{ab}	65^{b}
	1	84^{bcd}	87^{abcd}	79^{ab}	73^{ab}
	Mean	87	88	75	71
KC	1/4	87^{abcd}	94^{abc}	82^{a}	86^{a}
	1/2	91^{abcd}	91^{abcd}	88^{a}	80^{ab}
	3/4	86^{abcd}	94^{ab}	82^{ab}	82^{ab}
	1	95^{a}	90^{abcd}	82^{ab}	72^{ab}
	Mean	90	92	84	80
Grand Mean		87	90	79	78
CV[2]		15		20	

[1]Values within flask or jar treatments followed by common letter(s) are not significantly different using Duncan's Multiple Range Test at the 5% level.

[2]Coefficient of variation, in percent.

Table 2: The effects of sowing medium on the germination rate of *Nepenthes truncata* seeds sown in flasks and jars.[1]

Medium	Concentration	Germination Rate (GR) (% germination/day)	
		Erlenmeyer flask	Food jar
Control	(no nutrients)	1.3	1.2
MS	1/4	1.3^{e}	1.2^{abc}
	1/2	1.6^{cde}	1.2^{abc}
	3/4	1.5^{cde}	1.2^{ab}
	1	1.8^{b}	1.3^{a}
	Mean	1.6	1.2
WPM	1/4	1.4^{de}	1.1^{abc}
	1/2	1.5^{cde}	1.1^{bc}
	3/4	1.6^{bcde}	1.0^{c}
	1	1.5^{cde}	1.2^{abc}
	Mean	1.5	1.1
KC	1/4	1.7^{bc}	1.2^{abc}
	1/2	1.4^{de}	1.2^{abc}
	3/4	1.6^{abc}	1.2^{abc}
	1	1.6^{bcd}	1.1^{bc}
	Mean	1.6	1.2
	Grand Mean	1.5	1.2
	CV[2]	16	16

[1]Values within flask or jar treatments followed by common letter(s) are not significantly different using Duncan's Multiple Range Test at the 5% level.
[2]Coefficient of variation, in percent.

bination of seed soaking in sugar solution and Woody Plant Medium (WPM) with one-fourth salt concentration (17.5%) followed by Knudson C (KC) medium with three-fourth and full salt concentrations (14% and 13.8% respectively). MS medium with one-half and three-fourth salt concentrations gave comparably higher IGP (13% and 12.5%). In terms of FGP (Table 1), relatively strong interaction effects of soaking treatment and medium were observed in both flask and jar cultures while the concentration effects were weak. The best treatment for achieving highest FGP was a combination of hardening treatment (one cycle of soaking and drying) and MS (92.4%) or KC (92.2%) using flasks. On the other hand, GR (Table 2) was significantly affected by medium (for jar cultures) and medium and concentration interactions (for flask cultures). Sowing seeds in MS with full salt concentration using flasks resulted in the highest GR (1.83%). The results provided evidence that subjecting seeds to high osmotic concentrations does not necessarily decrease GR nor decrease the FGP for *N. truncata* seeds. This is contrary to earlier conclusions that GR is inhibited under high salinity conditions (Ayers, 1952, as cited in Arteca, 1996), and that GR decreases with decreasing external water potential (Hadas, 1976, and Hadas & Russo, 1974, as cited in Levitt, 1980). Toxicity because of the highly osmotic medium, however, was manifested in seedlings.

Germination time generally was within the range of 18 to 74 days (by which time the FGP had in general stabilized), and we note this period is shorter than the range of 28 to 180 days reported by Bickell (2000). FGP was higher and seedling growth was more advanced in flasks than in jars. The responses were probably affected by the differences in light transmission brought about by the type of glass as well as exchange of gases between the external and internal medium brought about by the type of closure. Erlenmeyer flasks probably permitted greater light transmission and the effects are manifested by the direction of shoot growth, leaf condition, as well as pitcher formation (see Figure 1).

Table 3: The effects of medium and concentration on pitcher formation, leaf condition, shoot length, and root length of *Nepenthes truncata* seedlings in flasks.[1]

Medium	Concentration 1/4	1/2	3/4	1	Mean
			Pitcher formation[3]		
Control					2.4
MS	1.8^{ef}	3.1^{c}	1.1^{fg}	1.0^{g}	1.7
WPM	3.0^{cd}	2.4^{de}	3.2^{bc}	1.6^{fg}	2.5
KC	4.0^{a}	3.8^{ab}	3.0^{cd}	2.4^{d}	3.3
Mean	3.0	3.1	2.4	1.6	2.5
CV[2]	27				
			Leaf condition		
Control					2.4
MS	3.8^{b}	4.6^{a}	2.4^{c}	1.1^{d}	3.0
WPM	2.1^{c}	2.1^{c}	2.4^{c}	2.2^{c}	2.2
KC	5.0^{a}	5.0^{a}	4.9^{a}	5.0^{a}	5.0
Mean	2.9	3.1	2.4	1.6	2.5
CV[2]	16				
			Shoot length		
Control					3.5
MS	3.1^{e}	4.5^{ab}	1.1^{g}	1.0^{g}	2.4
WPM	4.2^{bc}	2.4^{f}	3.5^{de}	2.0^{f}	3.0
KC	5.0^{a}	5.0^{a}	5.0^{ab}	4.0^{cd}	4.6
Mean	4.1	4.0	3.1	2.2	3.4
CV[2]	19				
			Root length		
Control					2.2
MS	1.0^{e}	1.6^{bc}	1.0^{e}	1.0^{e}	1.2
WPM	2.8^{a}	2.6^{a}	2.6^{a}	1.4^{d}	2.4
KC	1.8^{b}	1.2^{de}	1.0^{e}	1.0^{e}	1.3
Mean	1.9	1.8	1.6	1.2	1.6
CV[2]	24				

[1]Values within a parameter followed by common letter(s) are not significantly different using Duncan's Multiple Range Test at 5% level.

[2]Coefficient of variation, in percent.

[3]Data are provided for this and other rankings in dimensionless units, as described in the text.

Seedling growth and development were further evaluated based on pitcher formation, shoot length, leaf condition and root length. A scoring system of 1-5 was developed to rate each character. Pitcher formation was rated as follows: (1)absence of pitchers in all seedlings, (2)presence of slightly developed pitchers in majority of the seedlings, (3)equal distribution of seedlings with well-formed and slightly-formed pitchers, (4)presence of well-formed pitchers in majority of the seedlings, (5)presence of well-formed pitchers in all seedlings. Shoot length was rated as follows: (1)short stems without pitchers, (2)long stems without pitchers, (3)stems are longer than the pitchers, (4)stems are of equal length with the pitchers, (5)stems are shorter than the pitchers. Leaf condition was rated as follows: (1)incidence of chlorosis (white or brownish leaves), (2)incidence of deterioration such as yellowing and appearance of necrotic spots, (3)pale green and narrow leaves, (4)pale green but broad leaves, (5)dark green and broad leaves. Finally, root length was rated as fol-

lows: (1)root formation is negligible, (2)root structures are visible as tiny spots, (3)intermediate between (2) and (4), (4)roots are longer but shorter than (5) and appear thick due to root hairs (rare occurrence), (5) roots are extremely long and thin without root hairs (rare occurrence). The values for the scores are given in Table 3.

Root formation was inhibited in MS and KC. Avoidance to osmotic stress, water and nutrient deficit, and consequent disturbance in photosynthesis and respiration offers possible explanations to the inhibition of root growth in seedlings in MS. In KC, however, root inhibition was brought about by more active shoot differentiation that diverted the expenditure of energy to shoot growth rather than root formation due to absence of ion stress.

In this study, KC at one-fourth to three-fourth salt concentrations enhanced growth and development in all cultures. The survival and growth of *N. truncata* seedlings were drastically decreased by the high salt concentration in MS. Seedlings exposed to three-fourth up to full strength MS salts and one-fourth to one-half concentration of WPM salts showed severe abnormalities (chlorosis, root rotting, and browning of stems). The rest of the treatments (except those in KC) also showed abnormalities but they evolved more slowly. These effects were probably caused by ion stress (Levitt, 1980) although the scope of the study could not substantiate such claim. To be able to interpret these observations and to determine specifically the cause of such effects, extensive studies on mineral nutrition for *in vitro* cultures of *N. truncata* should be conducted.

In order to achieve faster and more synchronized germination for *N. truncata* seeds, applying the hardening treatment is recommended. This treatment can promote faster seedling growth and better transplant survival. However, this treatment can be combined with soaking in sugar solution to achieve early germination as well. The most satisfactory results with *in vitro* seed germination can be achieved with KC using the sterilization procedures developed in this study. Adjustments to the medium can be made to suit the germination conditions. Among all the media tested, KC produced the healthiest seedlings, which can be good source plants for mass propagation or for acclimatization.

Acknowledgment: The authors are grateful to: the Bureau of Plant Industry, Bago Oshiro, Davao City 8000, Philippines through Mr. Orlando Pascua (OIC Center Chief), and the Tissue Culture Lab personnel, especially Mr. Celso Carreon (Lab Supervisor) for the shared facilities and deployment of skills; and Ms. Bilma Fuertes for providing the needed plant and seed materials.

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Looking Back: CPN 25 years ago

In June 1979, James T. Robinson discussed the value and use of cultivar descriptions, and challenged horticulturists to use cultivar names to avoid the proliferation of poorly documented, confusing plant names: "What is needed now is the complete cooperation of both commercial and private CP growers for the proper naming and registration of CP cultivars. We have a fine opportunity to apply nomenclatural stability to the plants in our field of interest. Let's not let it escape us." Unfortunately, it is this editor's (BR) opinion that we have let the opportunity escape us almost entirely. Even though we now have an official carnivorous plant cultivar registration authority (the ICPS!), growers are still sloppily naming plants without registering them—the confusion continues!

Drosera spatulata var. *gympiensis*: the Formal Description of the "Hairy Sepal" Taxon from South-Eastern Queensland

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Keywords: new taxa, observations: *Drosera spatulata*, Queensland (Australia).

Introduction

Since the publication of Adrian Slack's first book in 1980 the world has become aware of morphological variation within *Drosera spatulata* throughout its geographical range. One novel variant that made a dramatic entrance into the horticultural world has short scapes less than 10 cm tall, which end in a congested raceme of large pink-petalled flowers. The peduncle, pedicels and sepals are conspicuously covered with pilose white hairs. This taxon has informally been known as the "hairy sepal form" and very little has been published about it, particularly its ecological niche. This article is intended to at least partially address this data gap with a formal description of this variant and observations of it in the wild.

Latin Description and Specimens Examined

Drosera spatulata Labill. Var. ***gympiensis*** R. Gibson & I. Snyder *var. nova.*

Affin. D. spatulata Labill., *sed inflorescentia breviore, 2-8(13) cm longa, floribus 2-13, pedunculo, pedicellis, et sepalis glanduloso-pilosis.*

Holotype: Opposite the south end of Fraser Island, Queensland, in swampy soil; wallam community; sea level, 18 January 1928, *Anon. 4* [AQ183256].

Paratype: 25 km NE of Gympie, along Tin Can Bay Road, Queensland, 6 March 2004, *R. Gibson & K. Hirsch 130* [BRI, NSW].

Description

Drosera spatulata var. *gympiensis* differs from the typical form of *D. spatulata*, with which it grows sympatrically, primarily in scape characters (whose characters, where they differ, are provided in parentheses), in the following ways: Herb with fibrous roots to 0.2 mm diameter. Stem very short. Leaves crowded in a flat rosette 12 to 25 mm diameter; lamina spathulate, narrowed, flat petiole, the whole 5-12 mm long by 2-3 mm wide, the under surface with appressed white eglandular hairs; stipules three-lobed, the central lobe broadly triangular with the free lobe to 1 mm long, the adjacent lobes narrowly triangular, to 3 mm long (see Figure 1, and Back Cover). Inflorescences (0-) 1-4, racemose, 1-sided, 2-4 (-8) cm long (2-30 cm long) with 3-6 (-13) flowers (2-20 flowers). Peduncle base eglandular pilose with white hairs 0.2 mm long above a sparse cover of white stalked eglandular hairs 0.04 mm long (almost glabrous with scattered glandular hairs to 0.05 mm long); upper peduncle, pedicels and sepals glandular and eglandular pilose with both glandular and eglandular white hairs 0.3-1.0 mm long above a sparse cover of white hairs 0.04 mm long (with a sparse cover of glandular and eglandular hair to 0.05 mm long). Bracts subulate to 1.6 mm long with a few glandular hairs to 0.3 mm long at the base, the remainder of the surface with a moderate cover of white eglandular hairs to 0.04 mm long (subulate to 1.5 mm long, with scattered scabrous eglandular hairs to 0.04 mm long). Pedicels terete 1.2-3.0 mm long (1.2-2.0 mm long). Calyx narrow ovate to narrow obovate, 3.0-3.6 mm long, (elliptic to narrow obovate, 2.0-2.5 mm long). Petals obovate, dark pink, 5 mm long × 3 mm wide (pale pink, 3.2 mm long × 2 mm wide) (see Figure 2). Styles

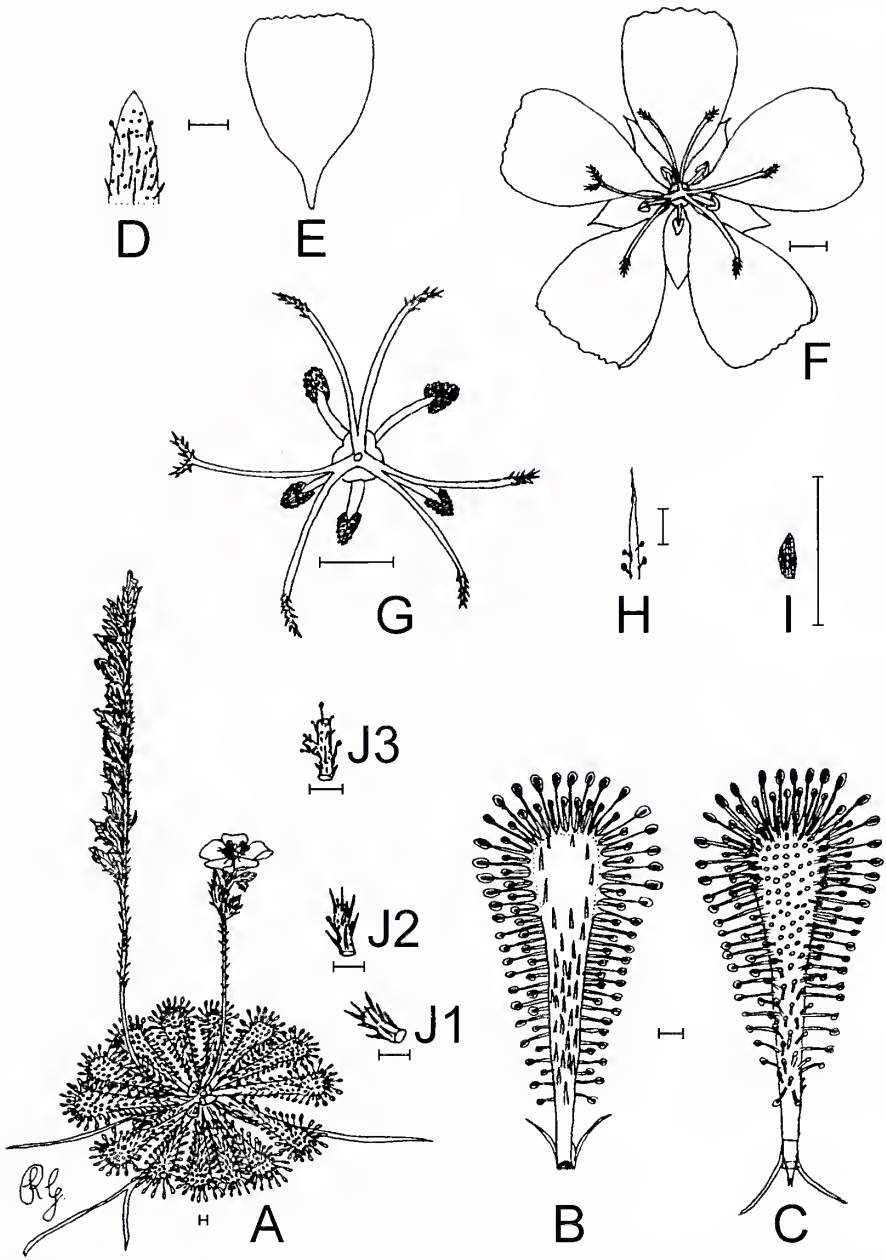

Figure 1: Line drawing of *Drosera spatulata* var. *gympiensis*. (A) Whole plant in flower showing the thick roots, (B) leaf under-surface showing appressed hairs, (C) leaf upper surface with the stipule pulled back, (D) free portion of the sepal with short and long-stalked glandular hairs, (E) detached petal, (F) open flower, (G) detail of the ovary, styles and stamens—note the rare bifid style apex, (H) bract, (I) ovoid seed and (J1-3) detail of the peduncle surface, J1 = peduncle base, J2 = peduncle below the inflorescence and J3 = peduncle amongst the flowers with a pedicel). Illustration by R. Gibson, June 1999. The scale bar represents 1 mm in all cases. Note the sepal apices in (F) vary in appearance due to the differing degrees that the tips reflex at anthesis. In *D. spatulata* it is typical for some sepal tips to remain reflexed in fruit.

Figure 2: Close up of the open flower of *D. spatulata* var. *gympiensis* in cultivation. Note the dark pink colour of the petals.

Figure 3: Plant of *D. spatulata* var. *gympiensis* in the wild, near Gympie. Note the white pilose hairs on the apex of the inflorescence. The sundews to the right are a form of *D. peltata*. The plants were photographed in early April.

3, bipartite to the base. Style segments, green to pink, 2-2.5 mm long, terete; the apex rarely bifurcated. Stigmas 0.5 mm long, minutely papillose. Seeds ellipsoid-cylindrical, black 0.4 mm long by 0.1-0.12 mm maximum diameter (black-dark brown, narrow ellipsoid-obovoid, 0.4 mm long by 0.06-0.08 mm maximum diameter). (See Figure 1.)

Distribution

Drosera spatulata var. *gympiensis* appears to have a limited natural range, found in south eastern Queensland north east of the city of Gympie where one of us (RG) has studied this taxon. The here-designated type specimen was collected about 40 km to the north, but *D. spatulata* var. *gympiensis* has not been found around the nearby city of Maryborough (150 km north of Gympie (B. Pierson, pers. comm. March 1999) and to date has not been collected in coastal wetlands south east of Gympie, where it could occur. In contrast the typical form of *D. spatulata*, informally called the "Kanto" type by Slack (1980), grows sympatrically with *D. spatulata* var. *gympiensis*, and is also found along the entire eastern Australian seaboard, and adjacent ranges and throughout Tasmania (Marchant and George, 1982). It also occurs along the western margin of the Pacific Ocean north from New Guinea to southern Japan (Slack, 1980).

Habitat

Drosera spatulata var. *gympiensis* grows in coastal and near coastal wetlands near the city of Gympie in South Eastern Queensland [26.10°S; 152.32°E]. One of us (R.G.) observed this variant in damp clay soil on the edge of a slash pine (*Pinus elliottii*) plantation and also in heathland along a nearby creek (see Figure 3). The plants were locally abundant in any one area and grew sympatrically with *D. burmannii, D. peltata* and the typical morphotype of *D. spatulata*. The two forms of *D. spatulata* were instantly recognisable and separable by their scapes. The typical taxon has virtually hairless scapes up to 30 cm tall with usually more than ten flowers. No intergrades were observed.

Discussion

The hairy sepal variant has become well known in cultivation over the last 15 years however it is poorly known in the wild. There have been few herbarium collections, of which the oldest I (R.G.) have seen was collected in January 1928 from the mainland Australia coast opposite Fraser Island (*Anon. 4* [AQ183256] BRI). This specimen has a short hairy scape with three pink petalled flowers. It was collected in wallam vegetation, a term for coastal heathland in southern Queensland that typically contains species of *Banksia* (Proteaceae) in the tree and shrub layer. The formal description of *Drosera spatulata* var. *gympiensis* is perhaps a bold step. However it appears warranted based on the distinct morphology and genetic isolation of this taxon within this species complex. A formal study of variation within the complex throughout its range is required, and has been given a great start by the detailed cytological work done by Kondo (1971) and by Salmon's (2001) detailed descriptions of variation within *D. spatulata* in New Zealand. Salmon described four forms of *D. spatulata* but noted that intergrades were found between them. No intergrades have been found between *D. spatulata* var. *gympiensis* and the typical form of *D. spatulata*, even though they grow sympatrically. Although, one of us (I.S.) has produced a completely fertile hybrid between these two forms that demonstrates that they are closely related.

Vegetatively *Drosera spatulata* var. *gympiensis* is virtually indistinguishable from the typical form of *D. spatulata*. The flower structure and seed morphology and genetic compatibility are also very close. Given these factors it was considered that varietal status of the "hairy sepal form" was the most appropriate taxonomic status. The formal description of this distinctive taxon is hoped to be an important step in the progressive understanding and analysis of variation within *D. spatulata*, and may make it possible to consistently apply taxonomic rank to the other members of this complex.

Acknowledgements

I (R.G.) wish to thank the director of The Queensland Herbarium for study access to the collection that provided data for this article. Suggestions from an anonymous reviewer were most appreciated and greatly helped with this paper.

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Literature Reviews

Boylan, J.D., Morris, J.E. 2003. Limited Effects of Barley Straw on Algae and Zooplankton in a Midwestern Pond. Lake and Reservoir Management. 19(3): 265-271.

The investigators explored the usefulness of straw from barley (presumably × *Elyhordeum*) as an aquatic mulch. Other researchers have claimed that barley can be used to control planktonic and filamentous algae. Using a set of replicated tests, the researchers attempted to demonstrate the effectiveness of barley straw but were unable to find consistent, useful effects. They concluded that, however, their inability to see such effects might have been the result of low oxygen levels in the decomposing straw, and that increasing the oxygen levels might facilitate beneficial attributes of the barley straw. Carnivorous plant growers attempting to cultivate *Aldrovanda* and aquatic *Utricularia* often bemoan the adverse effects of filamentous algae. Barley straw, in a properly oxygenated environment, might have value for the cultivation of these difficult aquatic species; such horticulturists are encouraged to read this paper and the papers cited therein. (BR)

Casper, S.J. 2004. *Pinguicula louisii* Markgraf (Lentibulariaceae) in Albania. Short Notice about a Nearly Unknown and Perhaps Neglected Butterwort. Haussknechtia 10: 239-245.

This paper provides new insight into an Albanian member of the taxonomically difficult *P. crystallina* group. The Albanian plants show "rounded corolla lobes" of the lower lip (vs. more or less emarginate ones in other populations) and a "long spur" (as long as or longer than the rest of the corolla). In addition, the lobes of the lower calyx lip are "nearly undivided and not spreading". The author revised material recently collected near the type locality of *P. louisii* as *P. hirtiflora* var. *louisii* (i.e. he does not follow the practice to include *P. hirtiflora* in *P. crystallina*). (JS)

Casper, S.J. and Stimper, R. 2004. Chromosome Numbers in the *Pinguicula crystallina-hirtiflora* Aggregate - a Preliminary Note. Haussknechtia 10: 247-251.

All investigated specimens (from Italy, Cyprus and Albania) had 2n=28 chromosomes. (JS)

Casper, S.J. 2004. Two New *Pinguicula* Species (Lentibulariaceae; *P. benedicta* group) from the Eastern Mountain Range of Cuba (Greater Antilles) with Reddish Flowers. Wulfenia 11: 1-13 (2004).

Pinguicula bissei and *P. caryophyllacea* are closely related to the rather variable *P. benedicta*. Both new species (each only known from the respective type collections) differ from *P. benedicta* by their pink or red-violet (or rarely white) corollas, while *P. benedicta* is said to be characterized by blue or blue-violet flowers. *Pinguicula bissei* has narrowly oblong, divergent and non-overlapping lower corolla lobes, *P. caryophyllacea* has oblong to obovate lower corolla lobes that tend to overlap in most specimens. (JS)

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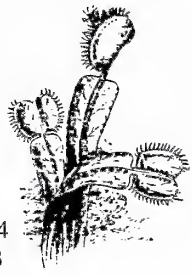

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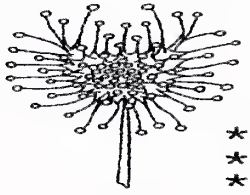

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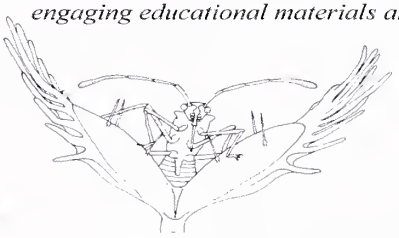

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News and Views

Doug Darnowski (ddarnows@ius.edu) wrote about one of the clones of *Aldrovanda vesiculosa* in cultivation: This note concerns the hardiness of *Aldrovanda* that originated from Girraween Lagoon, about 5 mi (8 km) south of Darwin in Australia's Northern Territory. I reported on the conditions at this site (Carnivorous Plant Newsletter, 2004, p80-81) 2004), and I have had excellent success growing plants for this form, which I obtained from a non-Australian source who was already cultivating it. These plants, I have found, are usually green to somewhat rust colored, though in cooler weather some plants will turn a bright red. (Other horticulturists who grow plants from this area record their original location with various names such as "Darwin, Australia," "NT, Australia," or "Girraween Lagoon.")

In the summer of 2004 I grew these plants with *Nymphaea* spp., *Nymphoides* spp., and *Azolla* spp. in a tank approximately 1 m long, 0.7 m wide, and 0.5 m deep (3 × 2 × 1.5 feet), containing 10-13 cm (4-5 inches) of our local iron-rich clay soil and filled with rain water. The tank also contained guppies and pond snails. The three plants at the start of summer produced over 50 turions by October, which were removed for storage in the refrigerator. However, a few turions were overlooked and spent the winter in the tank. Temperatures dropped to -20 to -23°C (-4 to -10°F) several times. I was surprised to find more than a half-dozen healthy turions germinating in March 2005. I would have expected the turions of this plant, originating from a tropical site where the normal annual minimum temperature is about 15°C, to have died under these conditions! It appears that for at least one tropical form of *Aldrovanda*, cold hardiness is unexpectedly impressive; and it would be interesting to test the hardiness of other forms from warmer parts of the world under similar conditions.

Katherine Henwood (oakenhead@att.net) gave a warning about throwing pots out too soon: Last year I purchased three new bare root *Cephalotus* plants from Meadowview to add to the one I already had. I potted them up in sand and peat and following advice, put them outside in the shade house. In short order, they appeared to die. Disconsolate that my original *Cephalotus* was also dwindling away, I left the pots sitting on the shelf in the shade house. That was October. Last week (March 16) I was about to dump the pots when I found that they all, including my original pot, had little green leaves and in one case a minute pitcher! So do not be in a hurry to dump "dead" pots! I live in Pacifica, which is on the California coast, just south of San Francisco. When the plants are a little larger, I will move them onto the table in the full sun with my *Sarracenia*.

John Hummer (naturejohnh@yahoo.com) wrote about observations he has made over the years: I have made some observations of the winter behavior of *Dionaea muscipula* and *Drosera capillaris*. During the winter, most other temperate perennials are truly dormant, but I have seen that these two species do not behave the same way. My observations are based on having grown them in cultivation for nearly thirty years, as well as observing specimens I have planted in the wetlands on my property in central Virginia.

On the shoreline of my pond, in the protected and sheltered areas where the sun's rays are unobstructed, I have observed that both species continue active growth (they produce new and fully functional leaves) during the winter months (see Figure 1, next page). This is especially true when they experience several weeks of somewhat milder winter conditions. This behavior is not what would strictly be considered winter dormancy. For example, in my studies of *Dionaea* during the winter season, I have found that any plant can be taken out of what appears to be its dormant state by simply moving it from its cool or cold conditions to a warm and sunny site—it will promptly resume its active growth within a short time. The only other North American species that does not enter winter dormancy is *Drosera brevifolia*. I have naturalized all the species of North American *Drosera* (except *D. linearis* and *D. anglica*) on my property, and with the exception of *Drosera capillaris* and *D. brevifolia*, these species all enter dormancy characterized by (1) a total absence of the ability to grow and produce functional leaves, and (2) a complete physiological change in the appearance and behavior of the plant.

Figure 1: *Dionaea* in January, with fully functional leaves. See note by John Hummer, page 62

Barry Rice (barry@carnivorousplants.org) wrote: Those with internet access may remember a big brouhaha that happened in 2001-2002 when a rancher in California repeatedly let cattle trespass onto privately owned land that has the southernmost-known *Darlingtonia californica* site. This site is the only place that the all-green *Darlingtonia* 'Othello' is known to occur. The trespassing cows repeatedly trampled the site and even ate my pollination experiments for the year. At the time, the US Forest Service shirked responsibility for the cattle (even though they sell grazing permits). Finally, after much complaining by the landowners, by holders of a conservation easement on the property, and by the carnivorous plant enthusiast community, the Forest Service pledged action to prevent future bovine damage. All was good.

Unfortunately, cows returned to the site in 2004. In response to a new barrage of complaints, the Forest Service put a new staff person on charge (Leigh Sevy, lsevy@fs.fed.us), and this staffer is responding as if the 2004 incidents are the first time any complaints have been made. Yes, it is a very frustrating situation, and big step backwards for the plants. I will be posting new developments (if and when they occur), on a web site that documented the first set of cattle intrusions: (http://www.sarracenia.com/land-abuse/bullscat.html). Keep tuned in!

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